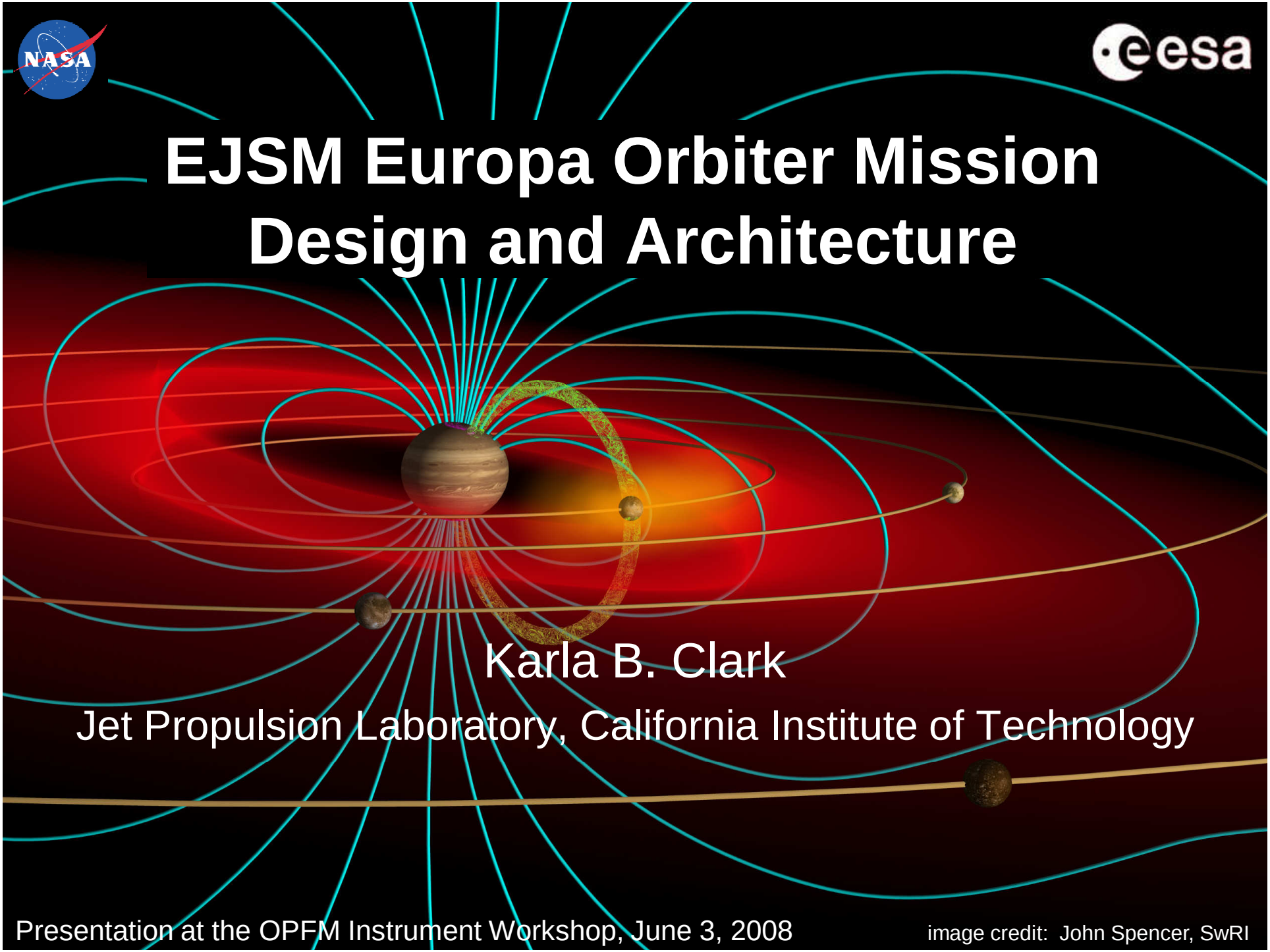


EJSM Europa Orbiter Mission Design and Architecture

Karla B. Clark

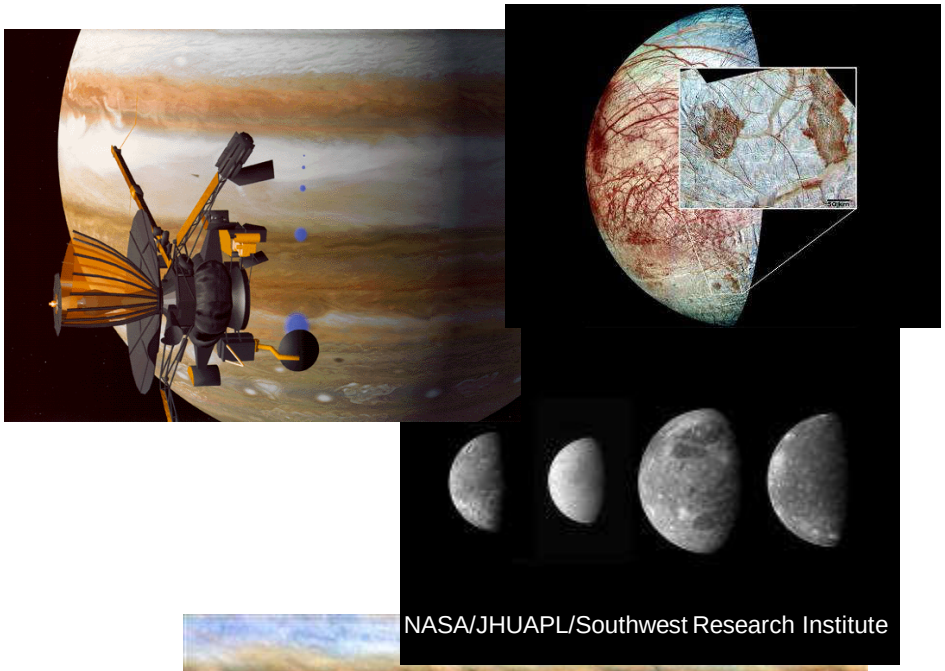
Jet Propulsion Laboratory, California Institute of Technology

Presentation at the OPFM Instrument Workshop, June 3, 2008

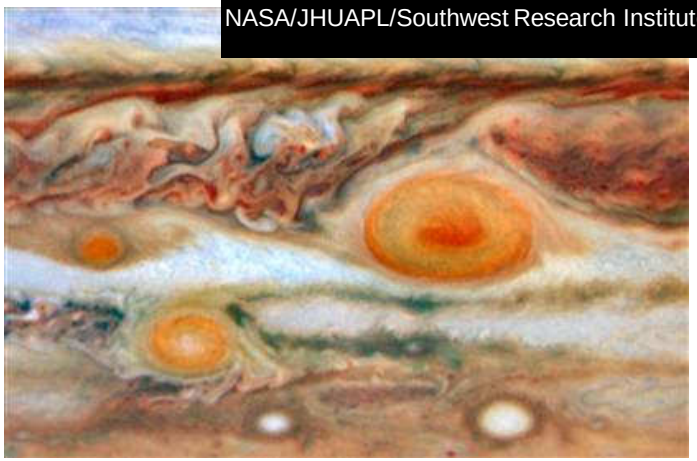
image credit: John Spencer, SwRI

Scientific Context

- 1995 – Galileo begins returning data on Jupiter and its Icy moons
- Galileo data is analyzed and augmented with data from Hubble Space Telescope and ground based observations
- Some questions are answered, many more are born
- Models are created and tested
  - Some are disproved or refined
  - Others remain unproven
- Hypotheses are developed
- Progress is slowed
  - Only small amounts of new data will become available until another mission visits the system

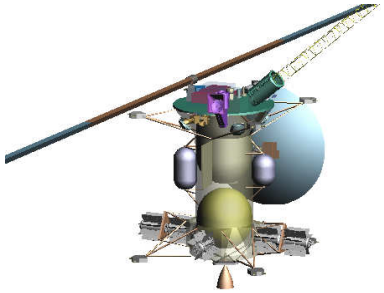


NASA/JHUAPL/Southwest Research Institute



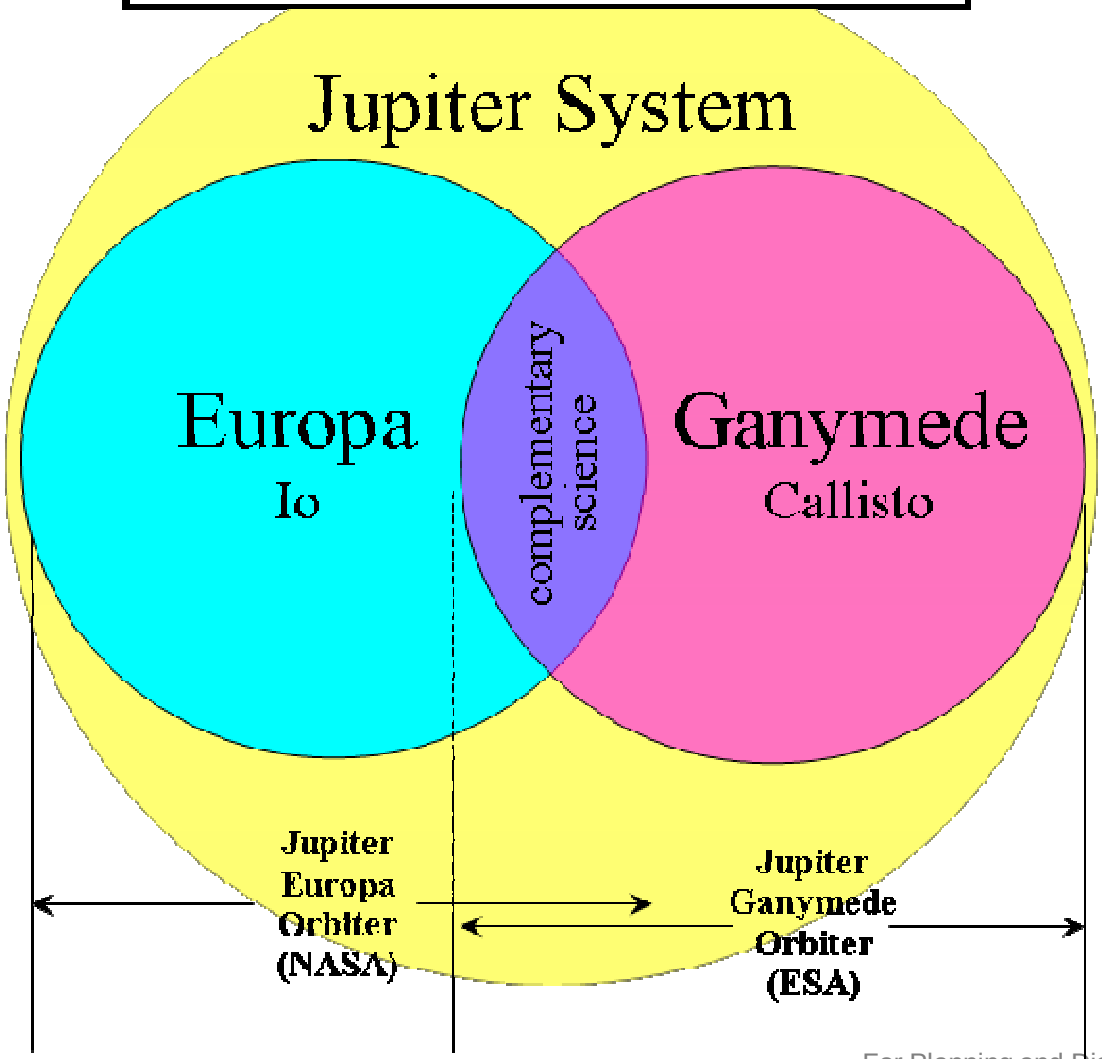
NASA / ESA / UC-Berkeley

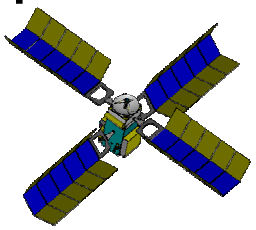
Europa-Jupiter System Mission Concept



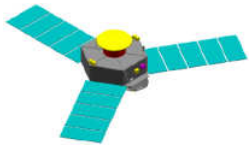
NASA Jupiter
Europa Orbiter

The Emergence of Habitable Worlds Around Gas Giants



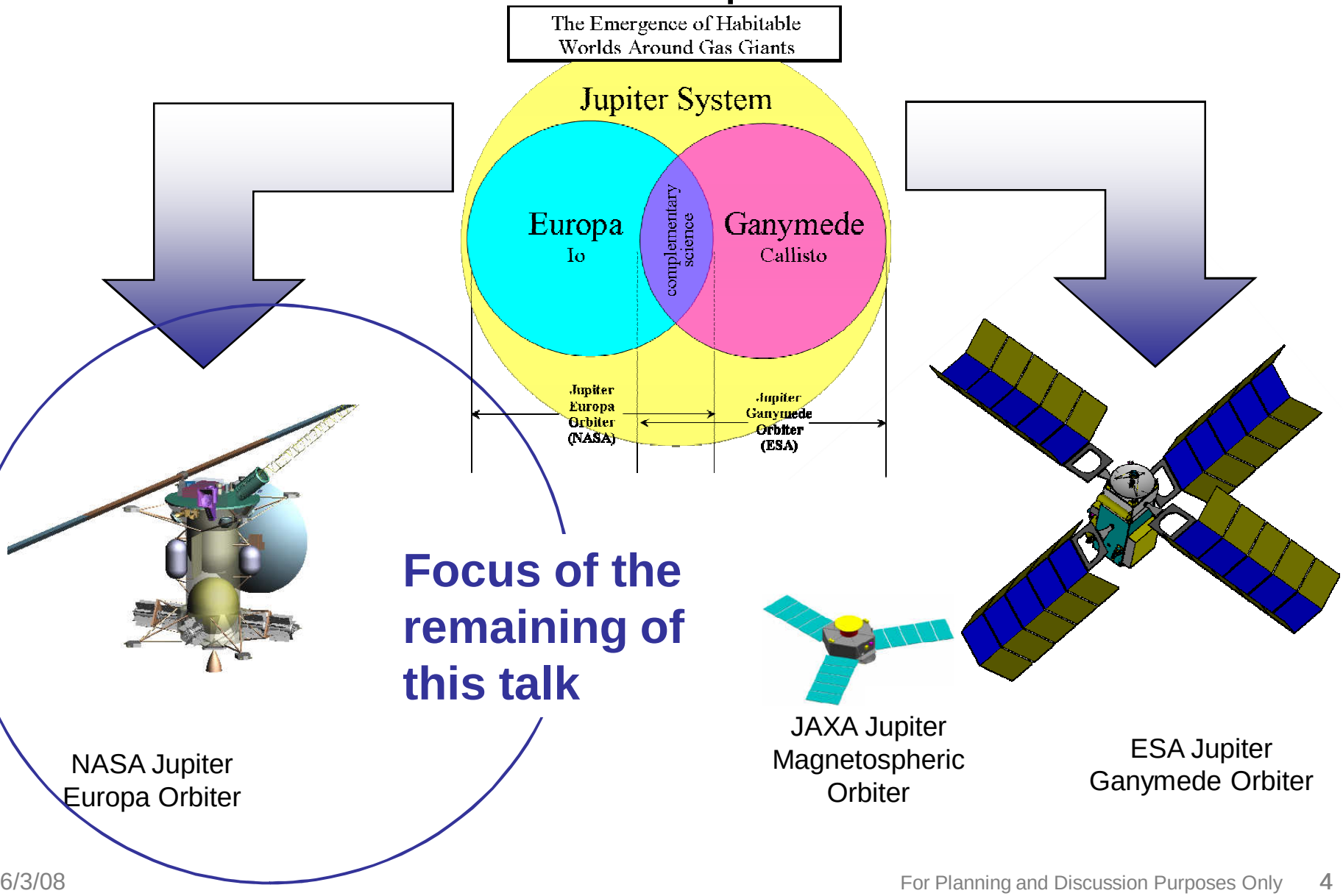


ESA Jupiter
Ganymede Orbiter



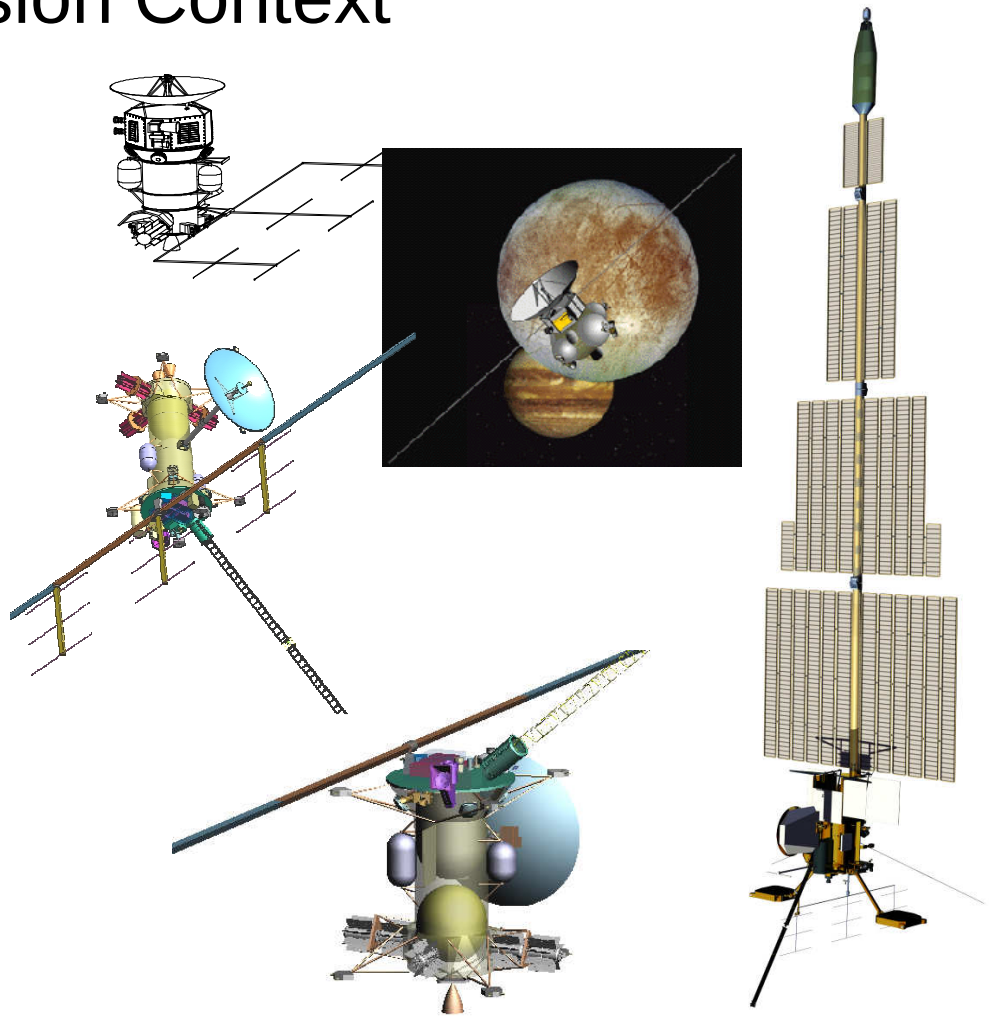
JAXA Jupiter
Magnetospheric
Orbiter

EJSM Decomposition



JEO Mission Context

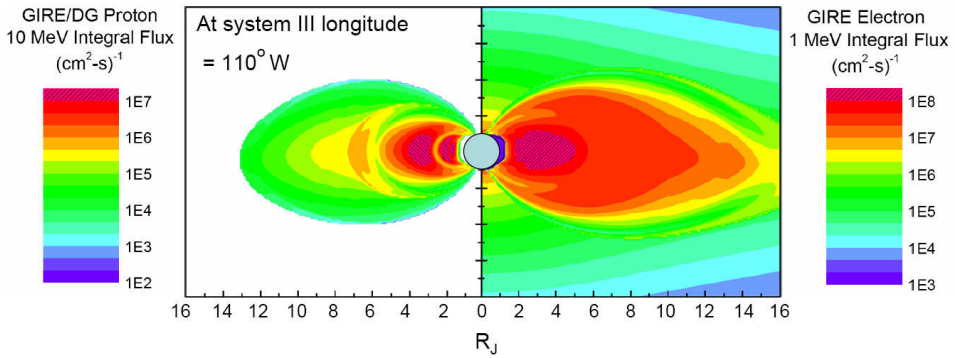
- 1997-2008 – 5 major NASA efforts and 1 JPL internal study to Europa exploration
  - Europa Orbiter EO-2001
    - Highly resource constrained
  - Jupiter Icy Moons Orbiter
    - Ambitious
  - Europa Geophysical Explorer
    - Return to conventional approach
  - Europa Explorer EE-2006 (JPL Internal)
    - Resolve challenging technical issues while requiring No New Technology
  - Europa Explorer EE-2007
    - Peer Review radiation approach
  - Jupiter Europa Orbiter JEO-2008
    - Find sweet spot

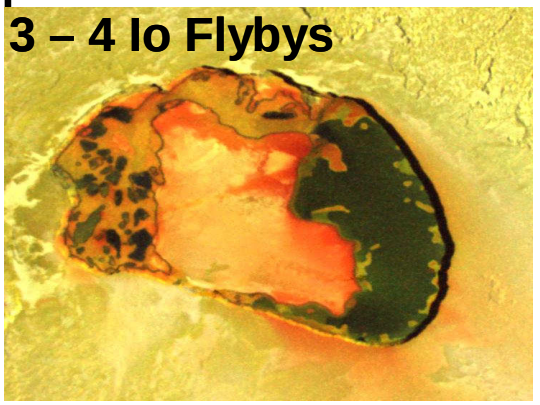


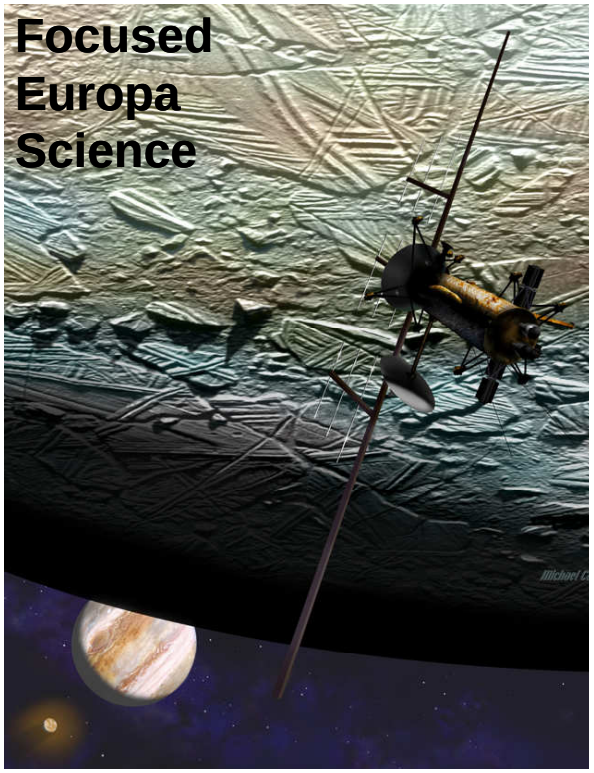
Four Science Definition Teams all concluded that an orbiter at Europa is essential for validating the hypotheses and answering the questions

2008 JEO Mission Concept

- **Concept:** Europa Orbiter with Jovian Satellite Tour
- **Launch Vehicle:** Atlas V 541
- **Power Source:** 5 MMRTG (531 W EOM)
- **Mission Timeline:**
  - Launch: 8/2016 (VEGA)
  - Jupiter arrival: 8/2021
  - Jovian system tour phase: ~18-24 months
  - Europa orbital phase: 105 days
  - Spacecraft final disposition: Europa surface Impact
- **Instruments:** 79 kg, 104 W
- Radiation Focused Design







JEO Baseline Interplanetary Trajectory

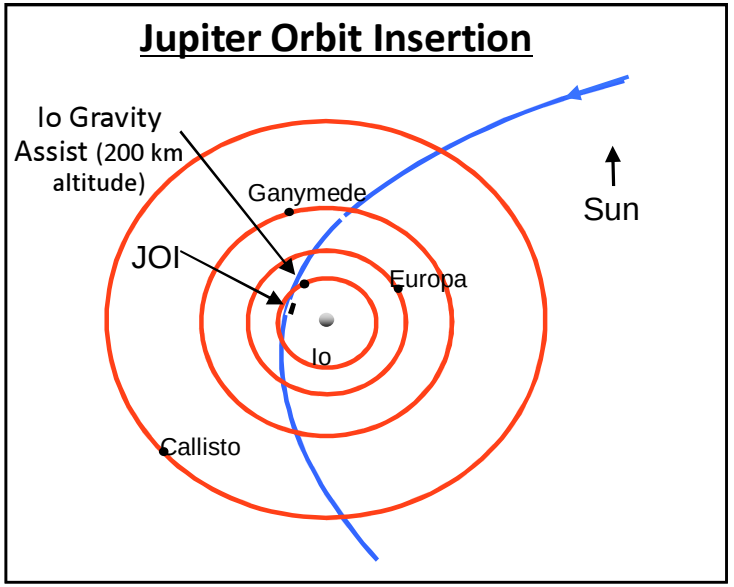
Earth GA
27 March 2019

Venus GA
3 September 2017

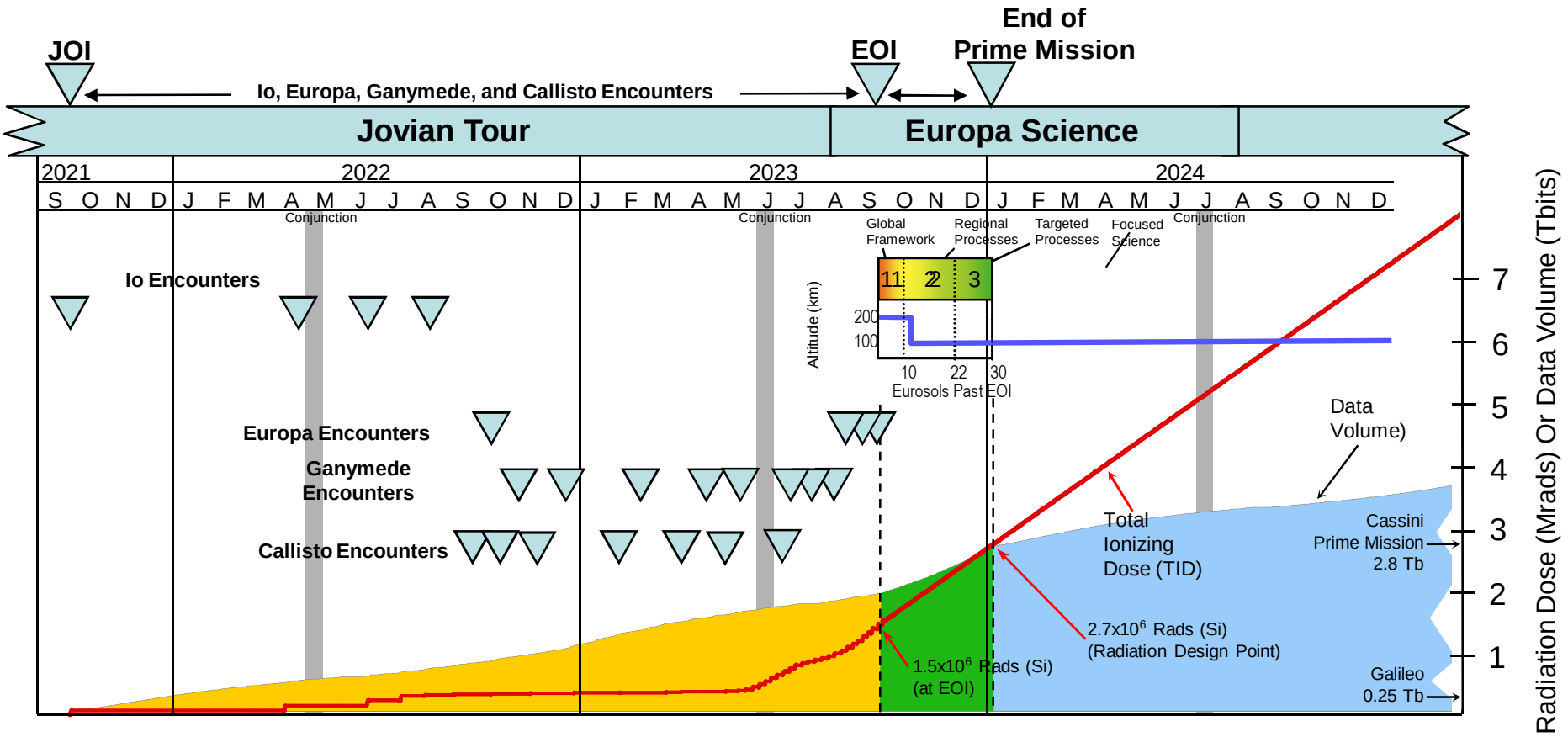
Launch
21 August 2016

DSM
(324 m/s)
12 April 2019

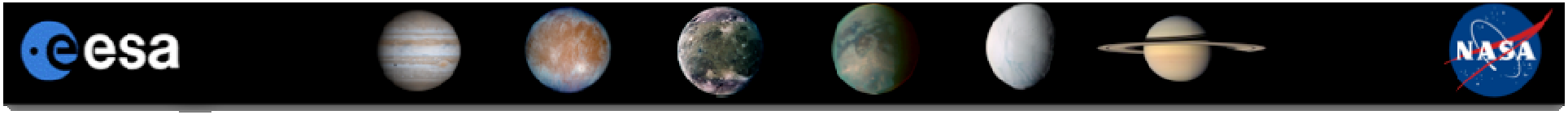
Jupiter Orbit Insertion
10 August 2021



Representative Science Mission Design



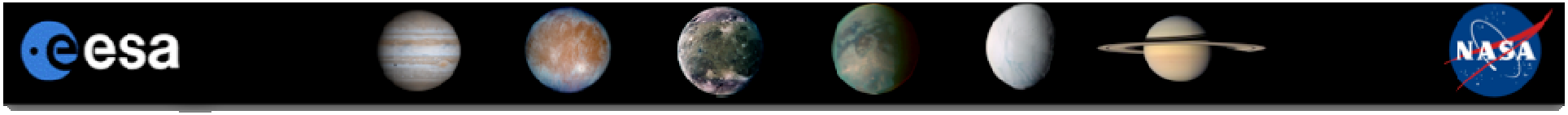
Jupiter system science opportunities, prioritized Europa science, and capable flight system enable substantial scientific data return.



Key Risk: Impact of Radiation and Planetary Protection on Design

Risk Area	Components	Mitigation	Impact
Radiation	a) Dose rate effects b) Sensor impacts (SNR) c) FPGA qualification d) Non-Volatile Memory capability e) Internal Electrostatic Discharge f) Design techniques	a) Quantify dose rate effects b) Use ASICs in place of FPGAs c) FPGA, memory and sensor radiation testing d) Document and disseminate design techniques and guidelines e) Early subject matter expert engagement	a) Reduced cost risk and uncertainty
Planetary Protection	a) Sensor sterilization capability b) Design techniques	a) Document design techniques and guidelines b) Early subject matter expert engagement	a) Reduced cost risk and uncertainty
Instrument Maturity	a) Level of information available for potential providers b) Wide range of experience of potential providers c) Development schedule	a) Document design techniques and guidelines b) Instrument provider workshops - early subject matter expert engagement c) Early and streamlined AO with confirmation review	a) Maximize time instruments can work with experts b) Reduce cost risk and uncertainty at “commitment”

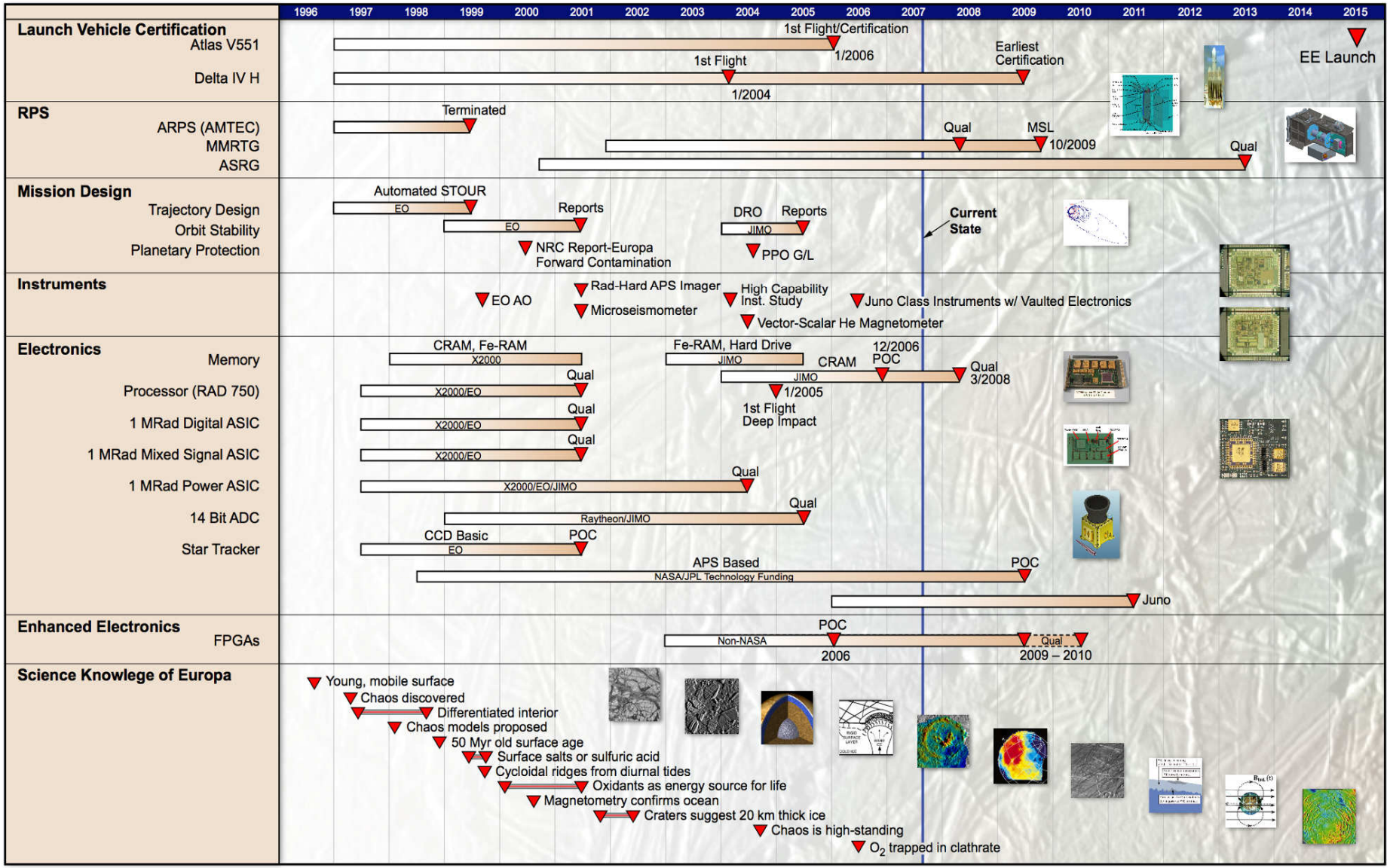
Radiation environment and planetary protection requirements require early and focused attention to mitigate risk

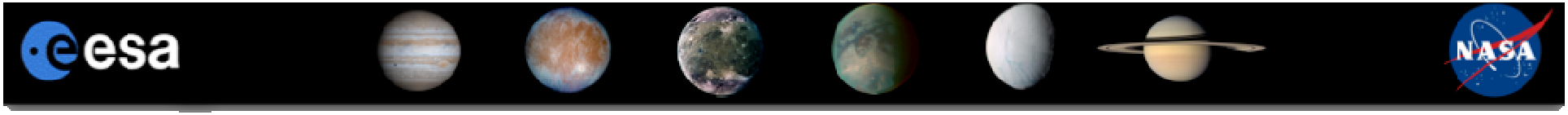


Radiation Challenge

- Europa missions experience significant radiation levels
  - Beyond any other NASA or ESA mission
- Ongoing investment by NASA, ESA, industry and other government agencies has matured technology and developed design approaches to deal with high radiation levels
- Risk mitigation starts early
  - Parts and materials are available
  - Design techniques can be applied
  - Operational techniques are employed

A Decade of Investment Has Reduced JEO Risk



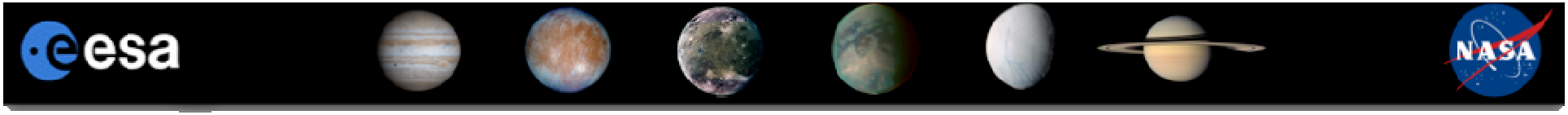


Current JEO Radiation Task Plan

- Individual items were identified and understood
- The phasing of tasks under the plan is driven by the following tentative milestones
  - Mission Concept Review
  - Instrument Announcement of Opportunity (AO)
  - Preliminary Mission and System Review (PMSR)
  - Preliminary Design Review (PDR)
- Priorities are set
  - Instrument AO preparation material
  - System engineering leading to PMSR
  - Engineering design leading up to PDR
- Identified activities for FY08 exceed monetary resources
  - Activities will continue into FY09

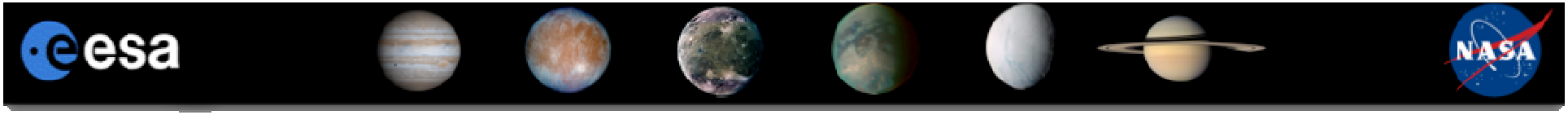
#	***Radiation Task***
1	System Reliability Model
	Parts & Circuit Models & Validation
	Systems Element Models & Validation
2	Environment and Shielding Models
	Environment & Shielding Model
3	Radiation Design & Analysis Methods
	Tutorials & Guidelines - Environment, Shielding, Parts, Materials, Circuits and Subsystems
4	Sensors and Detectors
	Science detectors: assessment and testing
	Engr detectors: assessment and testing
5	Parts Evaluation & Testing
	Testing strategy including TID, ELDRs
	Juno parts testing exetension
	Part/Device testing
6	Approved Parts and Materials

A prioritized plan has been made and is being executed



Planetary Protection Challenge

- End-of-Mission is Europa surface impact
- Sterilization is combination of pre- and post- launch sterilization
  - Pre-launch: heat, chemical or other type
  - Post-launch: external surfaces sterilized by radiation
- Some components are particularly concerning
  - Certain detectors
  - Batteries
- Protection from re-contamination is essential
- Early consideration of approach required for incorporation of requirements into design of components



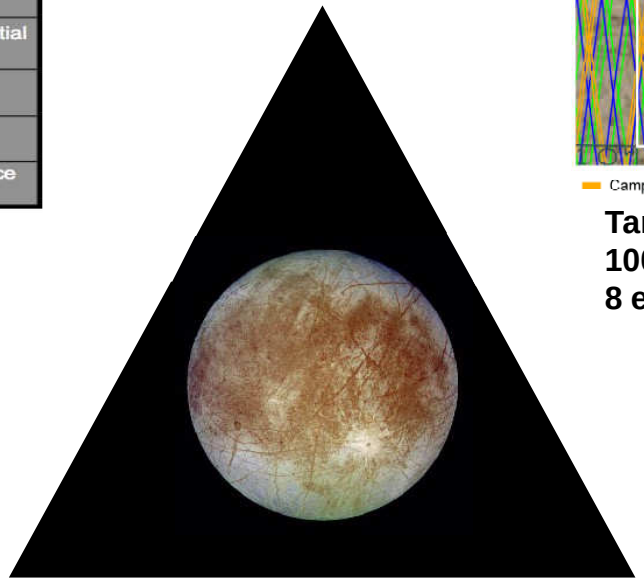
Instrument Community Engagement

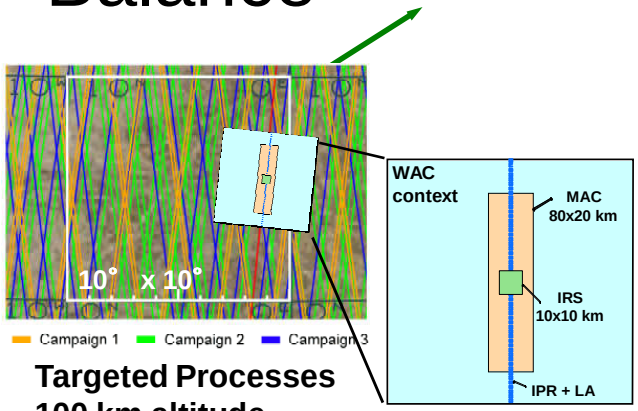
- Mission design elements and requirements are being addressed by Project
- Instruments would be selected by NASA HQ via Announcement of Opportunity
- To enable well understood, low risk proposals
  - Communicate primary issues
  - Communicate technology status and options
  - Document and communicate design mitigation strategies

Finding the Sweet Spot - Balance

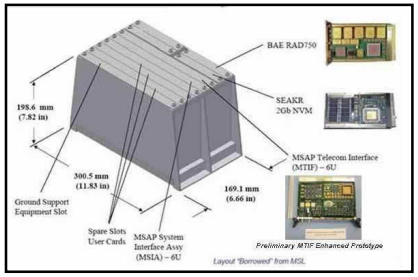
Science Value

5	Definitely addresses full science investigation.
4	May address full science investigation.
3	Definitely addresses partial science investigation.
2	May address partial investigation.
1	Touches on science investigation.
0	Does not address science investigation.





Targeted Processes
100 km altitude
8 eurosols ≈ 28 days



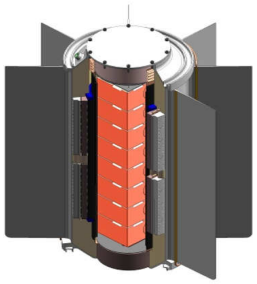
6U Cards Shielded Chassis

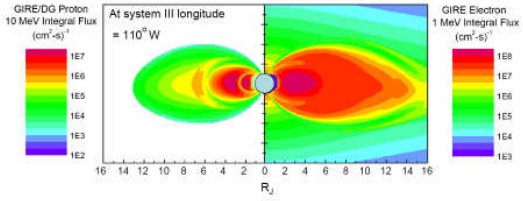
Resources

Mass

Power

Dollars





Risk

Cost Overrun

Launch Delay

Performance Degradation

Premature Failure